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## Socio-scientific issues (SSI) in initial training of primary school teachers: Pre-service teachers' conceptualization of SSI and appreciation of the value of teaching SSI

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### Abstract

In the present study, we designed and implemented a research-based initial training for primary-school teachers to help them understand what Socio-Scientific Issues (SSI) are and be able to teach them. Preliminary results show that the training facilitates the development of future teachers' understanding of SSI. The challenge is to see how these positive results translate into the ability to design and implement SSI activities in real primary school classrooms.

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**Keywords:** Socio-scientific issues (SSI); everyday science; pre-service teacher education; SSI teaching and learning; primary school.

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### 1. Introduction

The training program presented is embedded in the European project PreSEES<sup>†</sup> (Preparing Elementary and Secondary Pre-service Teachers for Everyday Science). The aim of the project is to engage pre-service primary school teachers in critical discussions on scientific current topics through Socio-Scientific Issues (SSI) and prepare them to teach SSI.

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SSI are socially controversial (or socially alive) topics or issues which have a scientific component but also incorporate other disciplines and interests (political, economic, ethical, etc.) and which involve the evaluation of moral and ethical aspects (Evagorou, Jimenez-aleixandre, & Osborne, 2012).

Today's society continuously faces socio-scientific issues that pose political and moral dilemmas, such as GMO, nano-technologies or climate change. Science education should provide opportunities for students to experience science in contexts similar or analogous to those contexts that they will find outside of the school, with the goal of achieving scientific literacy for all citizens (Albe, 2007).

In this sense, the SSI can serve as a good teaching and learning context, allowing students to understand the importance of science in everyday life and developing the ability to be critical consumers of scientific information (Kolsto, 2001). In addition, in an adequate teaching and learning scenario SSI encourage the participation in discussion and debate, provide a framework for understanding scientific content and the nature of science, and help the development of HOTS (Higher Order Thinking Skills), such as critical thinking and argumentation (Evagorou et al., 2012; Zeidler & Nichols, 2009).

Despite these recognized benefits, SSI are not generally included in the science classroom, much less in primary education, in which SSI seems, a priori, to represent a big challenge for teachers and students. What's more, scientific knowledge is usually presented as an indisputable and standardized knowledge (Jiménez-Aleixandre, 2010). Changing these understandings would require specific teachers' training.

In the literature in the field there has been an emphasis in the study of SSI regarding students' decision making, conceptual understanding and interest on science, but there is very little research regarding teacher education or about the difficulties to teach SSI in the classroom, specially at primary school level. Some studies have shown that teachers do not make connections between science and everyday life, as it is difficult to coordinate scientific data and social aspects of the problem (Zeidler, Sadler, Simmons, & Howes, 2005). This situation highlights the need of new ways to help teachers connect the scientific content with social issues.

How this training can be oriented, which difficulties may arise and what type of results are obtained, specifically in primary school education, is not an available knowledge. This is the direction in which the present study aims to contribute.

Given the issues presented, we outline two main objectives:

- Design and implement an innovative training program on SSI for pre-service primary school teachers.
- Investigate the development of pre-service teachers' conceptualization and appreciation of the value of teaching SSI across this training program.

## 2. Methodology

### 2.1. Context

In Spain, science education is part of the general training of pre-service primary school teachers, but not an specific itinerary. Senior pre-service teachers have never heard about socio-scientific issues, even less about teaching SSI. In this sense, their initial ideas on the topic were expected to be rather limited.

To overcome this an intensive training program was designed and implemented within a compulsory subject called "Practicum IV" (12 ECTS) in the last year (4<sup>th</sup> year) of the elementary pre-service teachers undergraduate degree. We devoted the last 3 sessions of the subject to the SSI training program (modules' implementation), from December 2013 to January 2014, in sessions of 1-2h (total 5 hours of face to face work + 2 hours of homework). 17 student teachers participated in the compulsory subject: 12 female and 5 male, ages 20-25.

Three extra volunteering sessions were held in small groups to design, implement and reflect on their own SSI lesson plans. They were held from January to April 2014, in sessions of 3 hours (9 hours of face-to-face work + 10 hours of tutored design). 3 students took part in the volunteering extra training.

The training program was collaboratively designed by international experts in Science Education within the EU project PreSEES. It was organised in three modules, which were translated, modified and adapted to our national context. The PreSEES modules have three learning objectives:

- (1) Understand the main characteristics of SSI: its controversial nature, the existence of uncertainty and the diversity of arguments that are used to back up the different positions.
- (2) Reflect on teaching SSI: the reasons to incorporate SSI's at Primary School and the specific pedagogy when designing and implementing SSI activities.
- (3) Design and implement SSI lesson plans with primary school students, and reflect on the process.

The training program was designed based on results of research on professional development of pre-service teachers, using the following teacher education strategies: (1) Making future teachers experience, as students, what they will have to teach, (2) Working on the pedagogical aspects with exemplary classroom teaching proposals, and (3) Supporting the design of SSI activities and the reflection on their implementations of SSI activities. Regarding the content, the modules emphasized the importance of recognizing the inherent uncertain and controversial aspects of SSI, and the different types of arguments that can be used when discussing or deciding about socio-scientific issues.

Session 1 and 2 were devoted to achieve objective 1 (understanding SSI), by participating as students in an SSI on “Global Warming”. In session 3 we focused on objective 2 (reflecting on teaching SSI), using the SSI topic “Edible Insects”. Objective 3 (designing and implementing SSI lessons) was to be achieved during the extra sessions 4, 5 and 6 (see Figure 1). More details of the modules’ implementation can be found in previous work (Evagorou et al., 2014) and in reports from the authors (Garrido & Couso, 2014).

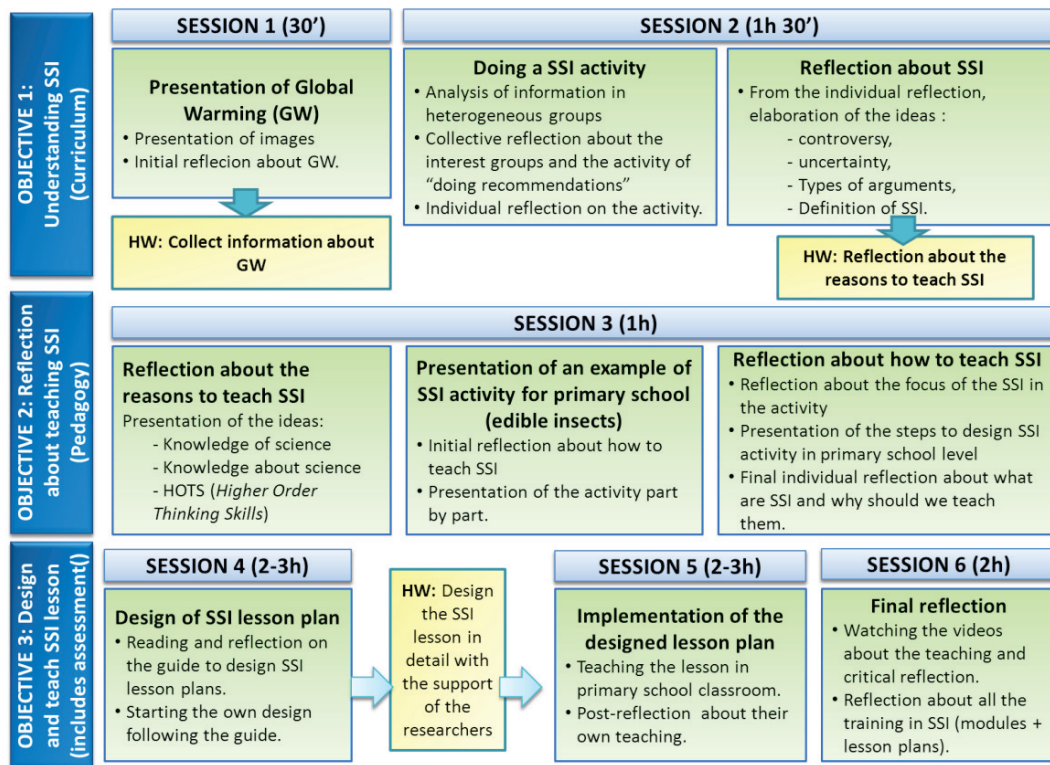


Fig. 1. Details of each session in the SSI training program.

## 2.2. Data gathering

Diverse type of data was gathered during the implementation of modules aiming to analyse pre-service teachers' ideas about SSI and perception of the value of teaching SSI. More specifically, we collected:

- (1) Pre-service teachers' pre and post individual reflections: collected before and after the modules (Pre and Post-intervention). Pre and post questions asked were: "1. *What do you think are SSI? Give examples.*" and "2. *Is it important to teach SSI in schools? Why?*"
- (2) Pre-service teachers' classroom productions (worksheets and written tasks).
- (3) Video and audio recordings of the discussions in the classroom.

The sample used for the study were only the student teachers that attended all compulsory sessions and completed all written tasks were (N=15).

## 2.3. Data analysis

To investigate the development of future teachers in their conceptualization of SSI and their appreciation of the purpose/value of teaching SSI we selected *Pre and post-intervention* extracts or quotes in which student teachers' model or concept of SSI was explicit and in which they expressed their appreciation of purpose of teaching SSI. The extracts selected, considered units of analysis, were categorized in a category system built from both the characteristics of SSI or reasons to teach SSI included in the literature (Albe, 2007; Driver, Newton, & Osborne, 2000; Erduran & Evagorou, 2012; Kolsto, 2001; Oulton, Dillon, & Grace, 2004) in addition to others emerging from data.

The theoretical and empirically based categories about the characteristics of SSI have been distributed in 4 dimensions: the *SSI Topic* (T), the *Nature of controversy* (C), the *Nature of Uncertainty* (U) and the *Arguments* (A). For each dimension (T, C, U or A), we have developed 4 exclusive categories ordered from lower (level 1) to higher (level 4) level of conceptualization of SSI (level 0 when it is not mentioned). For example, regarding the idea C, level 1 was given to those who identify controversy in general terms (i.e. "*different opinions on an issue*"), while level 4 was given to those who identify that it is a conflict of ideas between different social groups or within science (see Table 1).

Regarding the purposes for teaching SSI we identified four main purposes: being informed, developing HOTS (i.e. critical thinking), learning of science (scientific content) and learning about science (NOS). Taking these ideas into account, we have developed four categories of analysis when appreciating the *Purposes of teaching SSI* (P). These four categories are exclusive and ordered from the lowest (level 1) to the highest (level 4) appreciation of purpose. For example, in level 1 they only identify one superficial purpose for teaching SSI (i.e. being informed), while in level 4 they identify all main purposes of teaching SSI (development of HOTS, learning of science and learning NOS) (see Table 2).

Both for the conceptualization of SSI and for the purposes for teaching SSI, we have calculated the % of pre-service teachers that were at each level before and after the training program, identifying in each case what is the *most common pattern of evolution* present in our analysis and the % of student teachers following that pattern.

Idea	Category/level	Description of category
<b>TOPIC (T)</b>	<b>T1. Identifies 1 aspect of the topic (relevance, complexity, consequences, implications, ...)</b>	Mentions one of the aspects when defining SSI: - it is a current or relevant topic, - it is a problematic or a complex topic, - it affects different people/groups/sectors, - it implies personal decisions or depends on personal interests, ...
	<b>T2. Identifies 2 - 4 aspects of the topic OR identifies it is a topic with social or scientific implications</b>	Mentions 2-4 of the aspects included in T1 OR mentions that the topic has social or scientific implications
	<b>T3. Identifies 2 - 4 aspects of the topic AND identifies it is a topic with social or scientific implications</b>	Mentions 2-4 of the aspects included in T1 AND mentions that the topic has social or scientific implications
	<b>T4. Identifies 2 - 4 aspects of the topic, AND identifies it is a topic with socio-scientific implications</b>	Mentions 2-4 of the aspects included in T1 AND mentions that the topic has socio-scientific implications
<b>CONTRIVERSY (C)</b>	<b>C1. Identifies controversy in general terms</b>	Mentions that there are different opinions or points of view on an issue. It is seen as a conflict of ideas in general terms.
	<b>C2. Identifies controversy between science and society</b>	Mentions controversy as a conflict of ideas between science and society.
	<b>C3. Identifies controversy between different social groups OR within science</b>	Mentions the controversy as a diversity of points of view between different disciplines or social groups (i.e. politics, economics, ethics, ecology, etc.) OR within science (scientific community)
	<b>C4. Identifies controversy between different social groups AND within science</b>	Mentions the controversy as a diversity of points of view between different disciplines or social groups (i.e. politics, economics, ethics, ecology, etc.) AND it can also be within science (scientific community)
<b>UNCERTAINTY (U)</b>	<b>U1. Identifies uncertainty in general terms</b>	Mentions that the information available is not clear and precise (but diffuse, complex, open, without a unique answer/solution,...)
	<b>U2. Identifies the implications of uncertainty when making a decision</b>	Mentions that the information available is not clear and precise, and mentions that when dealing with uncertainty it's not easy to make a decision / there is not a completely "good" or "bad" decision (but better-reasoned decisions than others)
	<b>U3. Identifies at least one reason for uncertainty</b>	Mentions that the information available is not clear and precise, and gives one reason for uncertainty: - there is a lot (quantity), - it is not correct enough (quality), - it has different origins (source), - it is under construction or without consensus (lack of knowledge)
	<b>U4. Identifies the implications of uncertainty when making a decision AND one reason for uncertainty</b>	Mentions that the information available is not clear and precise (U1), identifies implications (U2) and gives at least one reason (included in U3).
<b>ARGUMENTS (A)</b>	<b>A1. Identifies arguments in general terms</b>	Mentions that people use arguments when having a point of view.
	<b>A2. Identifies one or more type of argument</b>	Mentions at least one example of the types of arguments (i.e. Authority, Based on evidence, Pros and cons, based on a personal experience...)
	<b>A3. Identifies the different possible types of arguments in a SSI</b>	Mentions the idea that there are different types of arguments in a SSI and gives at least one example of the types of arguments (i.e. Authority, Pros and cons, evidence, personal experience...)
	<b>A4. Identifies the different value of the different types of arguments</b>	Mentions the idea that there are different types of arguments AND that some have more value than others (I.e. an argument based on evidence is better than just based on authority)

Table 1: Categories and definition of categories about pre-service teachers' conceptualization of SSI

Category	Description of category
<b>P1. Being informed</b>	Mentions ideas such as: - being informed about current issues - being connected with their environment, - knowing the topics that are relevant for them - connecting with other subjects (inter-disciplinarily)
<b>P2. Developing HOTS</b>	Mentions at least one idea related to “HOTS” (Higher Order Thinking Skills), such as developing: - Open-minded, - A desire for more information, - A critical reflection on their own values and attitudes, - The ability to consider a wide range of information and points of view, - The ability to identify bias and be critical consumers of scientific information.
<b>P3. Developing HOTS, and learning about/of Science</b>	A. Mentions at least one idea of “HOTS” (included in R2) and one idea related to <b>learning ABOUT science</b> : - Raise awareness of the connection and interdependence of science and society. - Understand the importance of Science in everyday life. - Promote discussion and the inclusion of knowledge about the nature of science (NOS) and scientific knowledge. - Deepen on how people use science and recognize a human dimension in scientific practice. - Question the authority of science. - Confront the uncertainty of scientific knowledge. - Raise interrogations about the disagreement between the research community. Or B. Mentions at least one idea of “HOTS” (included in R2) and one idea related to <b>learning OF science</b> : - Understanding scientific information. - Make science more real and practical to integrate science content in the social context. - Engage students in authentic scientific practices
<b>P4. Developing HOTS, learning about Science and learning of Science</b>	Mentions at least one idea of “HOTS”, one idea of “learning ABOUT science” AND one idea of “learning OF science” (included in R2 and R3)

Table 2: Categories and definition of categories about pre-service teachers’ appreciation of purpose/value of SSI

### 3. Results

After the analysis of student teachers’ reflections, the following paragraphs present the results regarding their conceptualization of SSI and their appreciation of the value of teaching SSI.

#### 3.1. Pre-service teachers' conceptualization of SSI

Most pre-service teachers have shown a positive evolution in their ideas about SSI before and after the modules’ intervention. Initial conceptualizations of SSI were rather simplistic and limited, in most cases only referring to ideas about the *Topic* (i.e. it is current, relevant, etc.) and about *Controversy* (i.e. it generates different opinions, etc.). The *Uncertainty* and *Argument* dimensions were not mentioned by most teachers at the beginning of the modules, whereas they were included in most of their final reflections after the modules. Their final reflections also



included more sophisticated ideas regarding the *T* and the *C* than before the modules. Table 3 shows examples of two student teachers' reflections before and after the implementation, showing the categorization done in colour code.

Stud.	Answer to the question: "What do you think are SSI?"	
	Pre-Intervention	Post-Intervention
S.2	"I suppose that it would be like a conflict of ideas. That is, from a socially relevant issue, there can exist different positions or conflictive disagreements, as Catalanian independence or abortion."	"It is the moment in which you have to define an important issue (social or scientific) that affects all society in all areas. The controversy appears when it has to be decided why something happens and when a common agreement has to be achieved to find solutions. Reach an agreement from different ideas with the influence of personal interests causes controversies." "They are scientific topics without a correct answer (or solution) in which there are different positions (in favour or against), with different arguments based on data or on authority, and that affects different sectors (economics, politics, society...) such as abortion, climate change, stem cells or OMGs"
	Categories: T2, C1, U0, A0	Categories: T4, C1, U2, A2
S.8	"Inconsistencies between what is said from a social perspective and a scientific perspective toward a topic."	"They are currently relevant issues or problems that are seen from different scientific perspectives and that science does not have a single answer. Therefore, there are doubts and different points of view arise. Each position has an argument and some studies to be able to defend itself."
	Categories: T0, C2, U0, A0	Categories: T2, C3, U1, A1

Table 3: Examples of analysis of student teachers' conceptualization of SSI (S.2 and S.8) when answering to the question: "What do you think are SSI?" before (Pre-int) and after (Post-int) the intervention.

When analysing what is the pattern that represents more student teachers, we have identified that before the modules most pre-service teachers had a good idea about the *Topic* (T2) and a weak idea about *Controversy* (C1), but they didn't include any ideas of *Uncertainty* (U0) or *Arguments* (A0). After the modules, most student teachers were still in the same levels of *Topic* (T2) and *Controversy* (T1), but included ideas of *Uncertainty* (U1) and even achieved a good level in the category of *Arguments* (A2) (see Figure 2).

These results suggest that the modules had a positive impact on pre-service teachers' conceptualization of SSI, especially regarding the initially non-existing ideas of U and A. Although the general pattern doesn't show a difference in the ideas of T and C, when analysing their reflections individually we appreciate that most of pre-service teachers actually improved in most of the ideas, including T and C, which moved from lower levels (T1-2 and C1-2) before the modules to higher levels (T2-3 and C1-3) after the modules.

### 3.2. Pre-service teachers' appreciation of the purpose/value of teaching SSI

In general, student teachers have shown an appreciation of the purpose of teaching SSI, especially regarding HOTS and other easy ideas such as being informed, but they had difficulties identifying other purposes such as learning scientific content or nature of science. Reflections of most teachers haven't changed significantly before and after the modules, although some of them gave more complex ideas about HOTS and included new purposes in their final reflections. Table 4 shows examples of analysis of three student teachers' reflections before and after, according to the categories established.

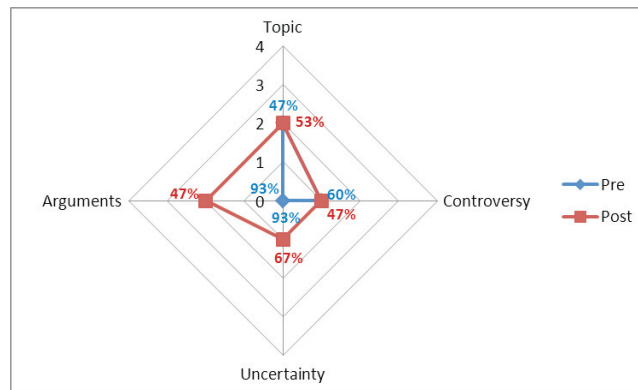


Figure 2: Most common pattern of conceptualization of SSI (pre and post) and % of student teachers that show that pattern.

Stud.	Answer to the question: “Is it important to teach SSI in schools? Why?”	
	Pre-Intervention	Post-Intervention
S.1	“Yes, because in order to educate active and critical citizens they have to work topics in which we don’t give them an absolute truth but diverse points of view that will let them have an opinion through their own criteria, making a judgment.”	“It is important in order for the students to get the scientific knowledge, to develop higher order thoughts (critical thinking, etc.) and about science, which have uncertainties, different points of view...”
	Category: P2	Category: P4
S.5	“Yes, not only because the student needs to know the realities, opposite and not, that surround him/her. But because this way we will develop in children critical thinking and auto-criticism that is necessary to be able to live and coexist in the current society.”	“Because this way we will develop critical thinking in children.”
	Category: P2	Category: P2
S.6	“Yes, you teach student to be critical, to show empathy and opinion in scientific topics. Know how science works, the pros and cons that it has, I think that it is very important that the boys and girls that will be future citizens of our society should know.”	“Yes, I think that it is important to develop critical thinking, knowing ideas of science that are complex, be conscious of the diversity of opinions, etc.”
	Category: P3	Category: P3

Table 4: Examples of analysis of pre-service teachers’ appreciation of purpose of SSI (S1, S5 and S6) when answering to the question “Is it important to teach SSI in school? Why?” before (Pre-int) and after (Post-int) the intervention.

When analysing their level as a group, identifying what is the pattern that represents more student teachers, results show that the most common pattern is described by a level 2 of appreciation of purposes (P2: developing HOTS) both before the modules (7 out of 15 student teachers, 47%) and after the modules (8 out of 15 student teachers, 53%). This shows that most pre-service teachers already had good initial ideas regarding their appreciation of HOTS as a purpose of teaching SSI, but didn’t identify other purposes, and this appreciation didn’t change after the modules.

We think that this is because some ideas on HOTS, such as critical thinking, already resonate with the framework on teaching for the achievement of competency (that is, the knowledge to solve real problems and apply it to new situations) that is present in the official teaching standards. On the contrary, “learning scientific content” or “learning NOS” (ideas included in levels 3 and 4) are more difficult ideas for pre-service teachers that they do not



relate to the teaching of SSI. Finally, we have to highlight that, although not being represented in the most general pattern, 45% of student teachers have improved their level of perception of the value of teaching SSI, which evidences some positive impact of the modules in this sense.

#### 4. Conclusions

The 17 participants of the SSI modules implemented within the PreSEES project have shown a positive appreciation of the training, doing all the assignments, reflections, and actively participating in all the sessions. In general terms, individual reflections show a positive impact of the modules in their conceptualization of SSI and appreciation of purposes of teaching SSI. The evolution of student teachers' ideas about SSI has been important in terms of richness and depth, including new aspects of SSI in their reflections, such as uncertainty and argumentation, and having higher levels of complexity in the four aspects analysed (topic, controversy, uncertainty and argumentation). Our results show that Module 1 has been effective for improving and enriching student teachers' concepts and ideas about SSI, evidencing that it is possible to achieve a rich and complex conceptualization of SSI in a short period of time and with students that have no previous knowledge on SSI, if using the right materials and strategies. This implementation is a good example in this sense.

Regarding the appreciation of purposes of teaching SSI, most of pre-service teachers remained in the same level of appreciation and only a few of them improved it. At the end of the modules, most pre-service teachers were able to appreciate the importance of critical thinking and other Higher Order Thinking Skills, such as argumentation or the ability to consider a wide range of points of view when teaching SSI, and realized that their students can benefit from participating in a SSI activity regarding these aspects. On the contrary, most of them didn't realize that these activities can also help students develop their knowledge of science and about science, probably because it is more difficult to relate these ideas to the aims of SSI activities. These results can also be explained by the higher emphasis given to the methodologies for teaching SSI, in Module 2, in comparison to the reasons to teach SSI, which were superficially explained. Regardless of it, our results signal that understanding the purposes for teaching SSI is challenging for pre-service teachers and therefore, an initial training on SSI should give special attention to these ideas if we want to achieve a complete and complex vision of SSI with pre-service teachers.

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